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DESCRIPTION

Component Mounting Method and Component Mounting Apparatus

Technical Field

The present invention relates to a component mounting method and a component mounting apparatus for manufacturing circuit boards by placing a multiplicity of components onto a circuit board.

Background Art

In recent years, needs for mounting apparatus for electronic components have been changing from rotary type high-speed mounters to robot type mounters that can flexibly be adapted to various forms of production, in terms of area productivity and component adaptability. Under such circumstances, for more improvement in productivity, those mounting apparatuses of which the number of placement heads to be mounted on one robot has evolved from one to pluralities and in which the suction nozzle to be used for each placement head is removable and interchangeable have been forming a mainstream.

In this type of electronic component mounting apparatus, there are some cases to use a so-called multiple board which is prepared by providing a plurality of circuits having an identical pattern on one circuit board, mounting a plurality of electronic components onto this circuit board,

and thereafter cutting the board according to individual circuit patterns so that a plurality of sub-boards having an identical circuit pattern are fabricated. It is noted that such a multiple board herein refers to a multiple board composed of a plurality of sub-boards in this DESCRIPTION.

The following methods are available as example of the prior art for placing electronic components onto such a multiple board composed of a plurality of sub-boards:

(1) A step repeat method including the steps of applying a step of placing particular components (hereinafter, referred to as placement step) to all the sub-boards, and after the completion of the placement step, moving to the next placement step; and

(2) A pattern repeat method including the steps of performing all the placement steps for one sub-board, and after the completion of all the placement steps, moving to the placement on the next sub-board.

Both of these step repeat and pattern repeat methods have been widely used since preparing only an NC program as a mounting program for only one sub-board makes it possible to develop the program for all components to be mounted on the circuit board by setting relative distances to other sub-boards.

The component mounting method for this multiple board is described below.

Fig. 7 shows a mounting procedure by the conventional step repeat method. Fig. 17 sequentially shows this placement procedure through component placement steps with an electronic component mounting apparatus having four placement heads (placement head Nos. 1 - 4) connected to one another.

In Fig. 17, the column "STEP NO." shows numbers sequentially assigned to steps of placement, where it is assumed that steps corresponding to the number of placement heads are involved in one-cycle operation from suction to placing of components by the four connected placement heads. The column "SUB-BOARD" shows, by numbers of sub-boards, on which sub-board on the circuit board a component is to be placed. The column "COMPONENT" shows components to be placed at respective steps. The column "PLACEMENT HEAD NO." shows placement heads to be used at individual steps. The column "SUCTION NOZZLE" shows which type of suction nozzle is used at individual steps. The type of suction nozzle to be used depends on the configuration and size of a component, where suction nozzles come in S (small), M (medium), and L (large) sizes. It is assumed here, as an example, that small-size components are sucked by the S-size suction nozzle, medium-size components are sucked by the M-size suction nozzle, and large-size components are sucked by the L-size suction nozzle. If there are some placement heads

that do not suck any component in one-cycle operation, the placement head actually does not suck and place any component, and so the fields of component and suction nozzle are marked with "-" in Fig. 17.

As shown in Fig. 17, in this placement procedure, components of the same type are placed for individual patterns in an order of a chip component C1 of a first pattern to C5 of a second pattern to C9 of a third pattern, ..., and upon completion of one placement step, the working step moves to a placement step for the next same type of chip components C2, C6, and C10. This placement step is performed for all components. It is noted that the suction nozzle is changed from S size for small-size components to M size for medium-size components after the placement of the chip component C12 of the third pattern, and changed from M size for medium-size components to L size for large-size components after the placement of SOP1 - SOP3 (where "SOP" is an abbreviation of Small Outline Package).

Next, the conventional pattern repeat mounting method is described.

Fig. 18 shows a mounting procedure according to the conventional pattern repeat method. Fig. 19 shows this sequential placement procedure through electronic-component placement steps with an electronic component mounting

apparatus having four placement heads (placement head Nos. 1 - 4).

In this placement procedure, as shown in Fig. 19, after all the placement steps for the first pattern are completed in the order of chip components C1 - C4, SOP1, and QFP1 of the first pattern (where "QFP" is an abbreviation of Quad Flat Package), the working step moves to the placement for the second pattern. Then, upon the completion of the placement for the second pattern, the working step moves to the placement for the third pattern. It is noted that the changing of suction nozzles is done respectively after the completion of the placement for one kind of components of each pattern. In the case of Fig. 19, the changing of suction nozzles is done three times for each pattern, totally eight times (the last one time is unnecessary).

However, in the case of the step repeat method, since only one among the four suction nozzles is used at all times, component suction and component placement are repetitively performed for every one component, causing the mounting time to be prolonged. Thus, the mounting method does not take full advantage of a multiple-head construction having a plurality of suction nozzles, resulting in an inefficient mounting method.

On the other hand, in the case of the pattern

repeat method, since the changing of suction nozzles is frequently done, the mounting time would be prolonged each time the time-consuming nozzle changing work is done to a plurality of times. Thus, the method results in an inefficient mounting method.

Applying such a mounting method to recently increasing large-scale multiple boards composed of, for example, 50 - 200 boards would cause the mounting apparatus to operate quite tediously. Since such an inefficient mounting method can hardly achieve any improvement in process time, there has been a keen desire for mounting methods of higher efficiency.

Moreover, in suction of electronic components to suction nozzles, even when the electronic components to be sucked are located at adjoining (succeeded) positions of component feeders as shown in Figs. 20A - 20D as an example, transfer heads need to be transferred one by one to perform the component suction because an array interval P of component feeders differs from an array interval L of the suction nozzles of the transfer heads. Besides, even if the array interval P of component feeders is equal to the array interval L of the suction nozzles, a shift of the electronic components from the array line would make it not to achieve their simultaneous suction. Furthermore, any difference in component thickness would also make the

simultaneous suction of electronic components no longer achievable.

Therefore, the component placement operation on suction nozzles cannot be done by a one-time simultaneous vertical operation of the suction nozzles, making it necessary to repetitively perform the operations of moving the transfer head to its corresponding component feed position and sucking the component for every suction nozzle as shown in Figs. 20A to 20D. As a result, it would take a longer time to make the electronic components held by the suction nozzles, which has been an obstacle to reduction in the mounting time.

The present invention having been achieved in view of these and other issues, an object of the present invention is to provide a component mounting method and a component mounting apparatus which allows the mounting time to be shortened by reducing such a suction preparation operation for suction nozzles as suppressing the changing frequency of the suction nozzles or adjusting the intervals of suction nozzles in the transfer head in the process of component mounting onto the multiple board.

Disclosure Of Invention

In order to achieve the above object, the present invention has the following constitution.

According to a first aspect of the present

invention, there is provided a component mounting method for placing components successively to component placing positions on a multiple board composed of a plurality of sub-boards by component holding devices equipped with a plurality of removable suction nozzles which is operable to hold the components, the method comprising:

in placing the components onto the board, applying a placement step to all the sub-boards, the placement step being a step of placing onto the board all of components that are holdable by at least one identical suction nozzle out of the plurality of suction nozzles; and

after completion of the placement step, changing the suction nozzle to another suction nozzle and moving to a next placement step, whereby component mounting for the individual sub-boards is carried out.

With this component mounting method, in the placement of components onto a multiple board, the suction nozzle is changed after the placement step of placing onto the multiple board all the components that can be held by the same suction nozzle is applied to all sub-substrates. Thus, the changing frequency of suction nozzles can be suppressed to a minimum, so that the component mounting time can greatly be shortened.

According to a second aspect of the present invention, there is provided a component mounting method

for placing components successively to component placing positions on a multiple board composed of a plurality of sub-boards by component holding devices equipped with a plurality of removable suction nozzles which is operable to hold the components, the method comprising:

in placing the components onto the board, applying a placement step to all the sub-boards, the placement step being a step of, with components of an identical type held on the suction nozzles, respectively, placing the plurality of held components onto the sub-boards, respectively, successively; and

after completion of the placement step, moving to a next placement step, whereby component mounting for the individual sub-boards is carried out.

With this component mounting method, in the placement of components onto a multiple board, components of the same type are held by the suction nozzles, respectively, and the working step moves to the next step after the placement step of continuously placing the components onto the individual sub-boards is applied to all the sub-boards. Thus, the operation of repeating the suction and placement for every one component by the conventional pattern repeat method is replaced by an operation of sucking at a time and then placing a plurality of components, allowing the component mounting time to be

shortened.

According to a third aspect of the present invention, there is provided a component mounting method for placing components successively to component placing positions on a multiple board composed of a plurality of sub-boards by component holding devices equipped with a plurality of removable suction nozzles which is operable to hold the components, the method comprising:

after completion of component mounting for one sub-board and in performing component mounting for a next sub-board in placing the components on the board, using suction nozzles that are the last used for placing-completed sub-boards, as they are, for the next sub-board, whereby component mounting for the individual sub-boards is carried out.

With this component mounting method, in the placing of components onto a multiple board, when the placement of components for one sub-board is completed and thereafter subsequently the placement of components for the next sub-board is performed, the suction nozzle used for the last sub-board for which the placement has been completed is used for the next sub-board as it is. Thus, the changing of suction nozzles for the sub-boards can be saved one time, so that the component mounting time can be shortened.

According to a fourth aspect of the present invention, there is provided a component mounting apparatus for mounting components onto a multiple board by using the component mounting method as defined in any one of the first to third aspects.

With this component mounting apparatus, in the placement of components onto a multiple board, since the mounting operation is performed efficiently so as not to be wasteful, a reduction in the component mounting time can be achieved.

According to a fifth aspect of the present invention, there is provided a component mounting method including: moving a transfer head on which a plurality of component holding devices operable to hold components are mounted, from component feed sections with a plurality of components arrayed thereon; making the components held by the component holding devices from the component feed sections; and lowering the component holding devices at over component placing positions of the circuit board, thereby placing the components held by the component holding devices onto the circuit board,

wherein array intervals of the component holding devices of the transfer head are coincident with at least one of component array intervals of the component feed sections and intervals of the component placing positions

on the board.

In this component mounting method, which is a component mounting method including the steps of laterally moving the transfer head that are to hold components, making the components held from the component feed section, and then mounting the components to component placing positions on the circuit board, components can be held by the component holding devices by moving the component holding devices vertically one time simultaneously at the time of taking out the components from the component feed section by virtue of the coincidence between the component array interval of the component feed section or the interval of the component placing positions on the board and the array interval of the component holding devices of the transfer head. Besides, in placing the components held by the component holding devices onto the circuit board, the components can be placed to desired positions on the circuit board by moving the component holding devices vertically one time simultaneously. As a result, the component mounting time can be greatly shortened.

According to a sixth aspect of the present invention, there is provided a component mounting apparatus comprising:

a transfer-head moving device for laterally movably supporting a transfer head operable to hold

components and place the components onto a board, the transfer-head moving devices being provided above the board on which the components are to be mounted;

a plurality of juxtaposed component holding devices provided on the transfer head and operable to hold the components;

a plurality of juxtaposed component feed sections having a plurality of components accommodated therein and operable to feed the components to the component holding devices; and

a component-holding-device moving mechanism disposed on the transfer head and operable to adjust array intervals of the plurality of component holding devices.

With this component mounting apparatus, in which the transfer head is equipped with a component-holding-device moving mechanism for adjusting the array interval of a plurality of component holding devices, the array interval of the component holding devices of the transfer head can be adjusted so as to be coincident with the component array interval in the component feed section or the interval of the component placing positions on the board. Thus, the components can be held by the component holding devices by moving the component holding devices vertically one time simultaneously at the time of taking out the components from the component feed section.

Besides, the components can be placed to desired positions on the board by moving the component holding devices vertically one time simultaneously at the time of placing the components held by the component holding devices onto the board. Thus, the component mounting time can be greatly shortened.

According to a seventh aspect of the present invention, there is provided a component mounting apparatus comprising:

a transfer-head moving device for laterally movably supporting a transfer head operable to hold components and place the components onto a board, the transfer-head moving devices being provided above the board on which the components are to be mounted;

a plurality of juxtaposed component holding devices provided on the transfer head and operable to hold the components; and

a plurality of juxtaposed and arrayed component feed sections having a plurality of components accommodated therein and operable to feed the components to the component holding devices,

wherein array intervals of the plurality of component holding devices of the transfer head are coincident with array intervals of the component feed sections.

With this component mounting apparatus, components can be held by the component holding devices by moving the component holding devices vertically one time simultaneously at the time of taking out the components from the component feed section by virtue of the coincidence between the array interval of the component holding devices of the transfer head and the component array interval of the component feed section. Thus, the component mounting time can be greatly shortened.

According to an eighth aspect of the present invention, there is provided a component mounting apparatus comprising:

a transfer-head moving device for laterally movably supporting a transfer head operable to hold components and place the components onto a board, the transfer-head moving devices being provided above the board on which the components are to be mounted;

a plurality of juxtaposed component holding devices provided on the transfer head and operable to hold the components; and

a plurality of juxtaposed component feed sections having a plurality of components accommodated therein and operable to feed the components to the component holding devices,

wherein array intervals of the plurality of

component holding devices of the transfer head are coincident with intervals of component placing positions on the board where the components held by the component holding devices are to be placed.

With this component mounting apparatus, in placing components held by the component holding devices onto a circuit board, the components can be placed to desired positions on the board by moving the component holding devices vertically one time simultaneously by virtue of the coincidence between the array interval of the component holding devices of the transfer head and the interval of the component placing positions on the board for the components held by the component holding devices. Thus, the component mounting time can be greatly shortened.

According to a ninth aspect of the present invention, there is provided a component mounting apparatus according to the sixth aspect, wherein the component-holding-device moving mechanism can adjust array intervals of the plurality of component holding devices of the transfer head so that the array intervals of the plurality of component holding devices become coincident with component array intervals of the component feed sections.

According to a 10th aspect of the present invention, there is provided a component mounting apparatus according to the sixth aspect, wherein the component-

holding-device moving mechanism can adjust array intervals of the plurality of component holding devices of the transfer head so that the array intervals of the plurality of component holding devices become coincident with array intervals of the component feed sections.

According to an 11th aspect of the present invention, there is provided a component mounting method including: moving a transfer head on which a plurality of component holding devices operable to hold components are mounted; making the components held by the component holding devices from a component feed section with a plurality of components arrayed thereon; and thereafter lowering the component holding devices at over component placing positions of a circuit board, thereby placing the components held by the component holding devices onto the circuit board, the method comprising:

before performing either one of an operation of holding the plurality of components by the plurality of component holding devices of the transfer head and an operation of placing the plurality of components, moving the component holding devices to adjust intervals between adjacent component holding devices at the transfer head so that the intervals between adjacent component holding devices become coincident with array intervals of the plurality of components targeted for the either one

operation; and

thereafter performing the either one operation by the plurality of component holding devices of the transfer head.

According to a 12th aspect of the present invention, there is provided a component mounting method according to the 11th aspect, wherein the either one operation is the operation of holding the plurality of components, and the array intervals of the plurality of components targeted for the either one operation are array position intervals of component array of the component feed section.

According to a 13th aspect of the present invention, there is provided a component mounting method according to the 11th aspect, wherein the either one operation is the operation of placing the plurality of components, and the array intervals of the plurality of components targeted for the either one operation are array position intervals of the component placing positions on the board.

According to a 14th aspect of the present invention, there is provided a component mounting method according to any one of the 11th to 13th aspects, further comprising:

before adjusting the intervals between adjacent

component holding devices, obtaining array position information as to the plurality of components targeted for the either one operation and, based on the obtained array position information as to the plurality of components targeted for the either one operation, determining the intervals between adjacent component holding devices in the transfer head; and

thereafter moving the component holding devices to adjust the intervals between the adjacent component holding devices so that the intervals between the adjacent component holding devices become the determined intervals between the adjacent component holding devices in the transfer head.

According to a 15th aspect of the present invention, there is provided a component mounting method according to any one of the 11th to 14th aspects, wherein the adjustment of the array intervals of the component holding devices of the transfer head is performed during move of the transfer head.

According to a 16th aspect of the present invention, there is provided a component mounting method according to the 14th aspect, wherein the obtaining the array position information as to the plurality of components is performed by reading array position information of the plurality of components previously

stored in a storage device.

According to a 17th aspect of the present invention, there is provided a component mounting method according to the 14th aspect, wherein the obtaining the array position information as to the plurality of components is performed by obtaining array position information as to the plurality of components recognized by a component-array-position-information recognition device of the transfer head.

According to an 18th aspect of the present invention, there is provided a component mounting apparatus which operates through: moving a transfer head on which a plurality of component holding devices operable to hold components are mounted; making the components held by the component holding devices from a component feed section with a plurality of components arrayed thereon; and thereafter lowering the component holding devices at over component placing positions of a circuit board, thereby mounting the components held by the component holding devices onto the circuit board, the apparatus comprising:

a component-holding-device moving mechanism provided on the transfer head and operable to move the component holding devices so as to adjust array intervals of the plurality of component holding devices;

a control section which can perform control for,

before performing either one of an operation of holding the plurality of components by the plurality of component holding devices of the transfer head and an operation of placing the plurality of components, driving the component-holding-device moving mechanism to move the component holding devices so as to adjust intervals between adjacent component holding devices at the transfer head so that the intervals between adjacent component holding devices become coincident with array intervals of the plurality of components targeted for the either one operation, and thereafter performing the either one operation by the plurality of component holding devices of the transfer head.

According to a 19th aspect of the present invention, there is provided a component mounting apparatus according to the 18th aspect, wherein the either one operation is the operation of holding the plurality of components, and the array intervals of the plurality of components targeted for the either one operation are array position intervals of component array of component feed section.

According to a 20th aspect of the present invention, there is provided a component mounting apparatus according to the 18th aspect, wherein the either one operation is the operation of placing the plurality of components, and the array intervals of the plurality of

components targeted for the either one operation are array position intervals of the component placing positions on the board.

According to a 21st aspect of the present invention, there is provided a component mounting apparatus according to any one of the 18th to 20th aspects, further comprising: an arithmetic section for, before adjusting the intervals between adjacent component holding devices, determining the array intervals of the plurality of components targeted for the either one operation based on array position information as to the plurality of components,

wherein the control section can perform control for driving the component-holding-device moving mechanism to move the component holding devices so as to adjust intervals between adjacent component holding devices so that the intervals between adjacent component holding devices at the transfer head become coincident with array intervals of the plurality of components targeted for the either one operation determined by the arithmetic section, and thereafter performing the either one operation by the plurality of component holding devices of the transfer head.

According to a 22nd aspect of the present invention, there is provided a component mounting apparatus according to any one of the 18th to 21st aspects, wherein

the control section is operable to adjust the array intervals of the plurality of component holding devices of the transfer head by driving the component-holding-device moving mechanism during the move of the transfer head.

According to a 23rd aspect of the present invention, there is provided a component mounting apparatus according to the 21st aspect, further comprising: a storage device for previously storing the array position information,

wherein the arithmetic section is operable to determine the array intervals of the plurality of components based on array position information as to the plurality of components read from the storage device.

According to a 24th aspect of the present invention, there is provided a component mounting apparatus according to the 21st aspect, further comprising: a component-array-position-information recognition device disposed on the transfer head and operable for recognizing the component array position information,

wherein the arithmetic section is operable to determine the intervals between adjacent component holding devices at the transfer head based on the component array position information as to the component placing positions on the board recognized by the component-array-position-information recognition device.

According to a 25th aspect of the present invention, there is provided a component mounting method according to the 12th aspect, wherein the either one operation is the operation of holding the plurality of components, and the array intervals of the plurality of components targeted for the either one operation are array position intervals of component array of the component feed sections,

the method further comprising: instead of moving the component holding devices so that the intervals between adjacent component holding devices at the transfer head become coincident with the array intervals of the plurality of components targeted for the either one operation, moving the plurality of component feed sections so that the array intervals of the plurality of component feed sections become coincident with the intervals between the adjacent component holding devices at the transfer head; and

thereafter performing the operation of holding the plurality of components at the plurality of component feed sections by the plurality of component holding devices of the transfer head.

More specifically, in the 25th aspect, the present invention provides a component mounting method comprising moving a transfer head on which a plurality of component holding devices for holding components thereon

are mounted, making components held by the component holding devices from component feed sections on which a plurality of components are arrayed, and thereafter lowering the component holding devices at component placing positions on a circuit board, whereby the components held by the component holding devices are mounted onto the circuit board, the component mounting method further comprising:

prior to the operation of holding the plurality of components by the plurality of component holding devices of the transfer head, moving the plurality of component feed sections so that array intervals between the plurality of component feed sections at the transfer head coincide with intervals between adjacent component holding devices, whereby the interval between the adjacent component feed sections is adjusted; and

thereafter performing the component holding operation by the plurality of component holding devices of the transfer head.

According to a 26th aspect of the present invention, there is provided a component mounting apparatus according to the 19th aspect, wherein the either one operation is the operation of holding the plurality of components, and the array intervals of the plurality of components targeted for the either one operation are array

position intervals of component array of the component feed sections,

the apparatus further comprising: instead of the component-holding-device moving mechanism, a component-feed-section moving mechanism for moving the plurality of component feed sections so that array intervals of the plurality of component feed sections become coincident with the intervals between adjacent component holding devices at the transfer head, and

wherein the control section is operable to perform control for, before performing the operation of holding the plurality of components by the plurality of component holding devices of the transfer head, driving the component-feed-section moving mechanism to move the component feed sections so as to adjust intervals between adjacent component feed sections so that the array intervals of the plurality of component feed sections become coincident with the intervals between the adjacent component holding devices of the transfer heads; and thereafter performing the operation of holding the plurality of components by the plurality of component holding devices of the transfer head.

More specifically, in the 26th aspect, the present invention provides a component mounting apparatus comprising moving a transfer head on which a plurality of

component holding devices for holding components thereon are mounted, making components held by the component holding devices from component feed sections on which a plurality of components are arrayed, and thereafter lowering the component holding devices at component placing positions on a circuit board, whereby the components held by the component holding devices are mounted onto the circuit board, the component mounting method further comprising:

a component-feed section moving mechanism for moving the component-feed section so as to adjust array intervals between the plurality of component feed sections; and

a control section for controlling, prior to the operation of holding the plurality of components by the plurality of component holding devices of the transfer head, so as to drive the component-feed section moving mechanism to move the plurality of component feed sections so that array intervals between the plurality of component feed sections at the transfer head coincide with intervals between adjacent component holding devices, whereby the interval between the adjacent component feed sections is adjusted; and thereafter to perform the component holding operation by the plurality of component holding devices of the transfer head.

Brief Description Of Drawings

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a component mounting apparatus as a first embodiment of the present invention;

Fig. 2 is an enlarged perspective view of a transfer head of the component mounting apparatus;

Fig. 3 is a schematic plan view of the electronic component mounting apparatus;

Fig. 4 is a view showing an order of placement by a task repeat method in an example of a multiple board composed of three sub-boards having an identical pattern;

Fig. 5 is a view sequentially showing placement steps by the task repeat method;

Fig. 6 is a view showing a multiple board having totally 16 sub-boards, longitudinally 4 × laterally 4;

Fig. 7 is a view showing an order of placement by an improved step repeat method in an example of a multiple board composed of three sub-boards having an identical pattern;

Fig. 8 is a view sequentially showing placement

steps by the improved step repeat method;

Fig. 9 is a view showing an order of placement by a reversal method in an example of a multiple board composed of three sub-boards having an identical pattern;

Fig. 10 is a view sequentially showing placement steps by the reversal method;

Figs. 11A and 11B are a schematic arrangement view and a perspective view of a transfer head in a second embodiment of the present invention;

Fig. 12 is a schematic arrangement view showing another example of the placement-head moving mechanism in the transfer head of the second embodiment;

Figs. 13A and 13B are views showing the relationship between the array interval of component feeders and the array interval of placement heads;

Figs. 14A and 14B are views showing the relationship between the interval of electronic-component placing positions on the circuit board and the array interval of placement heads;

Fig. 15 is an explanatory view showing an example of NC programs;

Fig. 16 is a schematic arrangement view showing a component-feeder moving mechanism in the electronic component mounting apparatus according to the foregoing embodiment of the present invention;

Fig. 17 is a view sequentially showing placement steps by the conventional step repeat method;

Fig. 18 is a view showing an order of placement by a conventional pattern repeat method in an example of a multiple board composed of three sub-boards having an identical pattern;

Fig. 19 is a view sequentially showing placement steps by the conventional pattern repeat method;

Figs. 20A, 20B, 20C, and 20D are views showing respective states of component placement operation by suction nozzles by a vertical motion of the suction nozzles; and

Fig. 21 is a block diagram related to the control section of the electronic component mounting apparatus according to the foregoing embodiment of the present invention.

Best Mode for Carrying Out the Invention

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Hereinbelow, preferred embodiments of the present invention are described in detail with reference to the drawings.

(First Embodiment)

Fig. 1 is a perspective view of an electronic component mounting apparatus which is an example of the component mounting apparatus as a first embodiment of the present invention, Fig. 2 is an enlarged perspective view of a transfer head of the electronic component mounting apparatus Fig. 1, and Fig. 3 is a schematic plan view of the electronic component mounting apparatus.

First, construction of an electronic component mounting apparatus 100 of the first embodiment is described.

As shown in Fig. 1, a pair of guide rails 14 for a circuit board 12 are provided at each of a loader section 16, a board holding section 18, and an unloader section 20 in the top center of a base 10 of the electronic component mounting apparatus 100. By synchronously driving transfer belts provided to these each-one pairs of guide rails 14, respectively, the circuit board 12 is transferred from the pair of guide rails 14 of the loader section 16 on one end side to the pair of guide rails 14 of the board holding section 18 located at a position where components, e.g., electronic components are mounted, and further from the pair of guide rails 14 of the board holding section 18 to the pair of guide rails 14 of the unloader section 20 on the other side. The board holding section 18 positions and holds the transferred-up circuit board 12, preparing for component mounting.

Y-axis robots 22, 24 are provided at both side portions, respectively, of the top surface of the base 10 upward of the circuit board 12, and an X-axis robot 26 is suspended between these two Y-axis robots 22, 24, where the X-axis robot 26 is advanceable and retreatable in a Y-axis direction by the drive of the Y-axis robots 22, 24. Also, a transfer head 28 is attached to the X-axis robot 26 so as to be advanceable and retreatable in an X-axis direction, which arrangement makes the transfer head 28 movable within an X-Y plane. In each of the robots, for example, ball screws are rotated forward and reverse by motors, and nut members screwed with the ball screws are advanceable and retreatable in their respective axial directions, where members to be advanced and retreated are fixed to the nut members.

The transfer head 28, which is mounted on the X-Y robot (one example of the transfer-head moving device) composed of the X-axis robot 26 and the Y-axis robots 22, 24 and which freely moves on the X-Y plane (e.g., a horizontal plane or a plane generally parallel to the top surface of the base 10), is so constructed that desired electronic components are sucked by suction nozzles 34 from a plurality of component feeders 30 as an example of the component feed section for feeding such electronic components as resistor chips or chip capacitors, or from a

component tray 32 as another example of the component feed section for feeding such relatively large-size electronic components as ICs such as SOPs or QFPs or connectors, and that the sucked electronic components can be placed to component placing positions on the circuit board 12. Such an electronic-component mounting operation is controlled by a control section 52 of Fig. 21 according to a mounting program stored and preset in a storage section 1001.

These component feeders 30 and component tray 32 correspond to an example of the component feed sections, where the array interval of components in the component feed sections refers to a distance between component feed ports of adjoining component feeders 30 in the case of the component feeders 30, or to a distance between accommodation recessed portions for accommodating the components in the component tray 32 in the case of the component tray 32.

The component feeders 30 are arrayed in a multiplicity on both sides (upper right side and lower left side in Fig. 1) in the transfer direction of the pair of guide rails 14. In each of the component feeders 30, are attached taped component rolls on which a multiplicity of electronic components such as resistor chips or chip capacitors are accommodated.

The component tray 32 can accommodate totally two

trays 32a which are longitudinal along a direction perpendicular to the board transfer direction of the pair of guide rails 14. Each tray 32a slides toward the pair of guide rails 14 according to the number of fed components so that the component takeout position in the Y direction is maintained at a constant position. On these trays 32a are placed a multiplicity of QFPs or other electronic components.

At a side portion of the circuit board 12 positioned to the pair of guide rails 14, is provided a recognition device 36 for detecting any two-dimensional positional shift (suction posture) of electronic components sucked by the suction nozzles 34 and allowing a correction on the transfer head 28 side so that this positional shift is canceled.

The transfer head 28, as shown in Fig. 2, is provided as a multiple head in which a plurality (four in the first embodiment) of placement heads (first placement head 38a, second placement head 38b, third placement head 38c, fourth placement head 38d) as an example of the component holding devices are laterally connected together. The four placement heads 38a, 38b, 38c, 38d are of the same construction, each placement head having a suction nozzle 34, an actuator 40 for driving the suction nozzle 34 into vertical (up-and-down) operation, and a pulley 46.

Forward-and-reverse rotation driving force of a θ-rotation motor 42a is transmitted to the pulley 46 of the first placement head 38a and the pulley 46 of the third placement head 38c by a timing belt 44, so that the suction nozzles 34 of both placement heads are put into θ-rotation (rotation around the axis of the suction nozzles 34) simultaneously. Also, forward-and-reverse rotation driving force of a θ-rotation motor 42b is transmitted to the pulley 46 of the second placement head 38b and the pulley 46 of the fourth placement head 38d by a timing belt 44, so that the suction nozzles 34 of both placement heads are put into θ-rotation simultaneously. Each actuator 40 is given by, for example, an air cylinder, and turning on and off the air cylinder to move the suction nozzle 34 vertically, or up and down, makes it possible to perform component holding or component mounting operation selectively. It has been arranged here that power of the θ-rotation motor 42a is transmitted by the timing belt 44, by which the suction nozzles 34 of the placement heads 38a, 38c are put into θ-rotation, respectively, while power of the θ-rotation motor 42b is transmitted by the timing belt 44, by which the suction nozzles of the placement heads 38b, 38d are put into θ-rotation, as shown in Fig. 2. However, such an arrangement is only an example, and it may be arranged that the first placement heads 38a, 38b, 38c, 38d are

equipped with θ-rotation driving motors, respectively, that drive those placement heads into θ-rotation individually. However, it is preferable that the number of θ-rotation driving motors that serve for drive into θ-rotation be smaller to reduce the weight of the transfer head 28.

The suction nozzles 34 of the placement heads are replaceable, and auxiliary suction nozzles for replacement are previously stored in a nozzle stocker 48 on the base 10 of the electronic component mounting apparatus 100. The suction nozzles 34 are provided in, for example, S-size nozzles for sucking very small chip components of about 1.0 x 0.5 mm, M-size nozzles for sucking 18 mm square QFPs, and the like, and put into use according to the type of electronic components to be placed.

Operation of the electronic component mounting apparatus having the above constitution is described below.

As shown in Fig. 3, when the circuit board 12 carried in from the loader section 16 of the pair of guide rails 14 is transferred to the board holding section 18, the transfer head 28 is moved laterally, i.e., within the X-Y plane by the X-Y robot to suck up desired electronic components from the component feeders 30 or the component tray 32, then moves to over the posture recognition camera of the recognition device 36, recognizing the suction posture of the electronic components. Then, based on the

recognition result, the θ-rotation motor is driven to put the suction nozzles 34 into θ-rotation, thereby making a correction operation for suction posture. Thereafter, the electronic components are placed to the component placing positions on the circuit board 12.

In suction of electronic components from the component feeders 30 or the component tray 32 by the suction nozzles 34, as well as in placement of electronic components to the component placing positions on the circuit board 12, the placement heads 38a, 38b, 38c, 38d make the suction nozzles 34 moved down by actuation of the actuators 40 from on the X-Y plane in the vertical direction (Z-direction). Also, the placement operation is performed with the suction nozzles 34 replaced, as required, according to the type of the electronic components.

By repeating the above operation of sucking electronic components and placing them onto the circuit board 12, the mounting of electronic components onto the circuit board 12 is completed. The circuit board 12 over the mounting is carried out from the board holding section 18 to the unloader section 20, while a new circuit board is carried in from loader section 16 to the board holding section 18 and the above operation is repeated.

It is noted here that mounting operations for electronic components are classified in speed in terms of

mounting cycle time, such as high, medium, and low speeds, according to the type (size and weight) of electronic components. This is due to the inertia of electronic components, where the classification is determined depending on the suction force of the suction nozzles 34 and the adhesion of the electronic components with the circuit board. Also, component suction is performed simultaneously by a plurality of placement heads, or component suction is performed with placement head by placement head.

Next, examples of the electronic component mounting method for multiple boards with the electronic component mounting apparatus according to the first embodiment of the present invention is described with reference to Figs. 4 to 10.

(Example 1)

First, mounting operation by a task repeat method is described as Example 1. The task repeat method refers to a method of repeating to a number of times corresponding to patterns the task of sucking components with a plurality of placement heads all simultaneously, or each individually, and then after recognition, placing all the components held on the placement heads onto the circuit board 12 simultaneously or individually.

Fig. 4 shows an example of a multiple board

composed of three sub-boards of an identical pattern for explanation's sake, where it is assumed that chip components C1 - C12, SOP1 - SOP3, and QFP1 - QFP3 are to be placed onto the pattern (first, second and third patterns) of each sub-board of this multiple board.

According to this mounting method, the mounting of the electronic components is carried out in an order of chip components to SOPs to QFPs as shown by arrows in Fig. 4. More specifically, as placement steps are shown sequentially in Fig. 5, the first steps include sucking up the chip component C1 to the first placement head 38a, the chip component C2 to the second placement head 38b, the chip component C3 to the third placement head 38c, and the chip component C4 to the fourth placement head 38d by S-size suction nozzles, respectively, moving the transfer head 28 to the component placing positions for the individual chip components on the sub-board of the first pattern, and placing the chip components C1 - C4 onto the board in this order. Steps following this include sucking up the chip components C5 - C8 by the placement heads 38a - 38d, respectively, moving and placing those components to the component placing positions on the sub-board of the second pattern, and likewise, further sucking up the chip components C9 - C12 to the placement heads 38a - 38d and placing the components to the component placing positions

on the sub-board of the third pattern in the similar way.

Next, for example, with the suction nozzle of the first placement head 38a changed from S to M size (where the placement head may be any other one), SOP1 is sucked up by the first placement head 38a and placed at the component placing position on the sub-board of the first pattern. Next, SOP2 and SOP3 are sucked up successively by the first placement head and placed at the component placing positions on each sub-board in the similar manner.

Then, with the suction nozzle 34 of the first placement head 38a changed from M to L size, QFPs 1 - 3 are placed at the component placing positions on each sub-board.

With this task repeat method, in the placing of electronic components onto three sub-boards, suction nozzles are changed only upon transitions from C12 to SOP1 and from SOP3 to QFP1. This minimizes the number of changes of suction nozzles, allowing electronic components to be placed on boards at high efficiency. Thus, a reduction in the electronic-component mounting time can be achieved.

With this task repeat method, the mounting time for placing electronic components onto a multiple board having, for example, longitudinally 4 × laterally 4, totally 16 sub-boards as shown in Fig. 6 can be calculated on trial as follows:

Successive placement of four types of chip components:

3 sec. × 16 patterns = 48 sec.

Nozzle change (S → M): 2 sec.

SOP Placement: 1.5 sec. × 16 patterns = 24 sec.

Nozzle change (M → L): 2 sec.

QFP placement: 1.5 sec. × 16 patterns = 24 sec.

Total: 100 sec.

(Example 2)

Next, mounting operation by an improved step repeat method is described as Example 2.

In this improved step repeat method, the order of mounting of electronic components is similar to that of the conventional step repeat method as shown in Fig. 7, where the mounting is carried out in the order of chip components → SOPs → QFPs as shown by arrows in Fig. 7. More specifically, as placement steps are shown sequentially in Fig. 8, the first steps include sucking up the chip component C1 to the first placement head 38a, the chip component C5 to the second placement head 38b, and the chip component C9 to the third placement head 38c by S-size suction nozzles, respectively, all simultaneously or each individually, moving the transfer head 28, and placing the chip components C1, C5, C9 onto the respective sub-boards in this order. Similarly, steps following this include sucking up the chip components C2, C6, C10 by the placement

heads 38a, 38b, 38c, placing those components onto the respective sub-boards, and further sucking up and placing the chip components C3, C7, C11 and sucking up and placing the chip components C4, C8, C12.

Next, with the suction nozzle 34 of the first placement head 38a changed from S to M size, SOP1 is sucked up by the suction nozzle 34 of the first placement head 38a and placed at the component placing position on the sub-board of the first pattern. Next, SOP2 is sucked up by the first placement head 38a and placed onto the sub-board of the second pattern, and further SOP3 is sucked up and placed to the sub-board of the third pattern in the similar manner.

Then, with the suction nozzle 34 of the first placement head 38a changed from M to L size, QFPs 1 - 3 are placed successively onto the respective sub-boards in the similar manner.

With this improved step repeat method, in the placing of electronic components onto three sub-boards, the number of component suction operations can largely be reduced as compared with the step repeat method that involves one suction operation for each component, allowing electronic components to be placed on boards at high efficiency. Thus, the mounting time can be shortened.

With this improved step repeat method, the

mounting time for placing electronic components onto a multiple board having longitudinally 4 × laterally 4, totally 16 sub-boards as shown in Fig. 6 in the similar manner can be calculated on trial as follows:

Successive placement of one type of components:

(3 sec. × 4 patterns) × 4 types of components = 48 sec.

Nozzle change (S → M):		2 sec.
SOP placement:	1.5 sec. × 16 patterns =	24 sec.
Nozzle change (M → L):		2 sec.
QFP placement:	1.5 sec. × 16 patterns =	24 sec.
	Total:	100 sec.

(Example 3)

Next, mounting operation by a reversal method is described as Example 3. The reversal method refers to an improved version of the pattern repeat method, where the order of use of suction nozzles for individual patterns is reversed from the order of use of suction nozzles for one-preceding pattern.

The order of mounting of components to be mounted according to this reversal method is described with reference to Fig. 9. The order of mounting for individual electronic components includes, as shown by arrows in Fig. 9, placing electronic components onto a sub-board of the first pattern, and then, as the suction nozzle that has

been used at the time point of completion of the placement step remains unchanged, beginning a placement step for the second pattern.

More specifically, as placement steps are shown sequentially in Fig. 10, the first steps include sucking up the chip component C1 by the first placement head 38a, the chip component C2 by the second placement head 38b, the chip component C3 by the third placement head 38c, and the chip component C4 by the fourth placement head 38c by S-size suction nozzles, respectively, moving the transfer head 28 to the component placing positions on the sub-board of the first pattern, and placing the chip components C1 - C4 onto the board in this order. Thereafter, with the suction nozzle 34 of the first placement head 38a changed from S to M size, SOP1 is sucked up by the first placement head 38a and placed at the component placing position on the sub-board of the first pattern. Subsequently, similarly, with the suction nozzle 34 of the first placement head 38a changed from M to L size, QFP1 is placed at the component placing position on the sub-board of the first pattern.

Next, the placing of electronic components for the sub-board of the second pattern is performed, where while the suction nozzle (L size) for QFP1, which has been the last placed to the sub-board of the first pattern, is

used as it is without being changed, QFP2 is first placed onto the sub-board of the second pattern. Upon completion of the placing of QFP2, SOP2 is placed with the suction nozzle changed from L to M size, and further the chip components C5 - C8 are placed with the suction nozzle changed from M to S size.

Subsequently, for the sub-board of the third pattern, while the S-size suction nozzle is used as it is without being changed in the similar manner, the chip components 9 - 12 are first placed onto the sub-board of the third pattern. Then, SOP3 and QFP3 are placed.

Carrying out the placing in this way eliminates the need for changing the suction nozzle upon completion of the placing step onto one sub-board, allowing the number of changes of suction nozzles to be largely reduced. Thus, electronic components can be placed onto the board with high efficiency, and the mounting time can be shortened.

With this reversal method, the mounting time for placing electronic components onto a multiple board having longitudinally 4 × laterally 4, totally 16 sub-boards as shown in Fig. 6 in the similar manner can be calculated on trial as follows:

Successive placement of four types of chip components: 3 sec.

Nozzle change (S → M): 2 sec.

SOP placement: 1.5 sec.

Nozzle change (M → L): 2 sec.

QFP placement: 1.5 sec.

Sub-total: 10 sec.

10 sec. × 16 patterns = 160 sec.

Total: 160 sec.

(Comparative Example 1)

For comparison's sake, mounting times by the step repeat method and by the pattern repeat method are given below.

First, the mounting time by the step repeat method is as follows:

For one type of component:

1.5 sec. × 16 patterns × 6 types of components = 148 sec.

Nozzle change (S → M): 2 sec.

Nozzle change (M → L): 2 sec.

Total: 152 sec.

(Comparative Example 2)

Also, the mounting time by the pattern repeat method is as follows:

Successive placement of four types of chip components: 3 sec.

Nozzle change (S → M): 2 sec.

SOP placement: 1.5 sec.

Nozzle change (M → L): 2 sec.

QFP placement: 1.5 sec.

Nozzle change (On → S): 2 sec.

Sub-total: 12 sec.

(12 sec. × 16 patterns) - (last nozzle change: 2 sec.) = 190 sec.

Total: 190 sec.

Table 1 lists the mounting times by all the individual mounting methods described above. As shown in Table 1, the task repeat method, the improved step repeat method, and the reversal method are capable of largely reducing the number of component suction operations as compared with the step repeat method, and of largely reducing the number of nozzle changes as compared with the pattern repeat method. Further, particularly with the task repeat method and the improved step repeat method, the mounting time can be reduced remarkably, allowing the throughput of equipment to be improved.

It is noted that the mounting time shown in Table 1 is an example of trial calculation under the above-described conditions, and when the component mounting is performed under other different conditions, there are some cases where more remarkable mounting-time reduction effects can be obtained in the mounting time of the individual Examples as compared with the mounting time of Comparative

Examples.

Table 1:

	Mounting method	Number of Component suction operations	Number of times of nozzle change	Mounting time
Example 1	Task repeat	48	2	100 sec.
Example 2	Improved Step repeat	48	2	100 sec.
Example 3	Reversal	48	32	160 sec.
Comparative Example 1	Step repeat	96	2	152 sec.
Comparative Example 2	Pattern repeat	48	47	190 sec.

(Second Embodiment)

Next, an electronic component mounting apparatus according to a second embodiment of the present invention is described.

Fig. 11A is a schematic arrangement view showing the construction of a transfer head 29 of the second embodiment. The transfer head 29 of the second embodiment is given by a placement-head moving mechanism 900 (one example of the component-holding-device moving mechanism) in which four placement heads 39, i.e. 39a, 39b, 39c, 39d, as an example of the component holding device having a ball screw mechanism, i.e. a ball screw 50, a motor 54, and clutches 56a, 56b, 56c, 56d are provided so as to be

advanceable and retreatable each along one direction. The rest of the construction is the same as in the first embodiment.

These placement heads 39 can be moved to desired positions by controlling the turn-on and -off of the motor 54 and the clutches 56a, 56b, 56c, 56d provided for the placement heads, respectively, according to instructions from the control section 52, so that intervals L_1, L_2, L_3 between the placement heads can be controlled independently of one another, allowing the intervals to be set to desired ones. Fig. 11B shows details of the clutches 56a - 56d. The clutches 56a - 56d are of the same structure and so illustrated as a clutch 56. The clutch 56, having a two-divided structure adapted to sandwich the ball screw 50 from both sides, is movable along four guides 104 parallel to one another in either direction indicated by an arrow 106 between an engagement position where the clutches 56 sandwiches the ball screw 50 from both sides to be engaged with the ball screw 50, and a disengagement position where the clutches 56 separates from the ball screw 50 on both sides to be disengaged therefrom. Air is supplied to a cylinder 103 through an air pipe 102 by the control section 52 controlling the turn-on and -off of an air valve 101 connected to an air supply source, and the clutch 56 is positioned to the engagement position to be engaged with

the ball screw 50 or the disengagement position to be disengaged therefrom, by actuation of the cylinder 103. While the clutch 56 is engaged with the ball screw 50, the clutch 56 is advanced and retreated in the axial direction of the ball screw 50 by forward and reverse rotation of the ball screw 50 due to forward and reverse rotation of the motor 54.

Also, a placement-head moving mechanism 901 shown in Fig. 12 may also be used as another example of the component-holding-device moving mechanism for changing the distances, or array interval, of the placement heads 39a - 39d. In the arrangement shown in Fig. 12, a ball screw 50a is fixed unrotatable, where reference numerals 105a, 105b, 105c, 105d denote hollow motors which engage with the ball screw 50a by themselves and rotate around the ball screw 50a. Under the control by the control section 52, the hollow motors 105a - 105d are actuated individually and independently of one another, making the placement heads 39a - 39d advanced and retreated along the ball screw 50a individually and independently, by which the intervals between the placement heads 39a - 39d can be adjusted.

By virtue of the arrangement that the intervals between the individual placement heads are made variable as shown above, the following effects can be produced.

First of all, given that the array intervals of

component arrays of the component feeders 30 that feed electronic components are M_1, M_2, M_3 as shown in Fig. 13A, intervals L_1, L_2, L_3 of the placement heads can be made coincident with the array intervals M_1, M_2, M_3 of the component feeders 30. As a result of this, in sucking electronic components 60 by the suction nozzles 34, the electronic components can be sucked up by the suction nozzles 34 of all the placement heads simultaneously and collectively. In more detail, as shown in Fig. 2, by simultaneously driving the actuators 40 of all the placement heads to thereby lower all the suction nozzles 34 simultaneously and collectively, four electronic components can be sucked and held simultaneously and collectively by the four suction nozzles 34. Also, by driving the actuators 40 of all the placement heads not simultaneously but sequentially one by one to thereby lower all the suction nozzles 34 sequentially and in succession, the four electronic components can be sucked and held sequentially by the four suction nozzles 34 without moving the placement heads within the X-Y plane.

Also, even when component feeders 30 of electronic components to be placed are not adjoining, that is, a component is sucked also from a component feeder 30 apart therefrom by the interval M_3 beyond component feeders 30 that are not targeted for component suction as shown in

Fig. 13B, electronic components can be sucked simultaneously even from the distant component feeder 30 by appropriately changing the interval (L_3 in the figure) between the placement head 39a and the placement head 39b so that the interval becomes coincident with the interval M_3.

Therefore, the suction of components by the individual suction nozzles 34 can be completed by a one-time simultaneous up-and-down motion of the individual placement heads, so that the component suction time can considerably be shortened, compared with the arrangement that components are sucked one by one for each suction nozzle 34.

Secondly, in placing electronic components held by suction nozzles onto a circuit board, as shown in Fig. 14, the placement of the electronic components 60 onto the circuit board can be completed by a one-time simultaneous up-and-down motion of the individual placement heads by virtue of the arrangement that the intervals L_1, L_2, L_3 of the placement heads are made coincident with the component array intervals N_1, N_2, N_3, respectively, of the electronic components to be placed, i.e., that $L_1 = N_1$, $L_2 = N_2$, and $L_3 = N_3$. In more detail, as shown in Fig. 2, by simultaneously driving the actuators 40 of all the placement heads to thereby lower all the suction nozzles 34

simultaneously and collectively, four electronic components can be placed onto the circuit board 12 simultaneously and collectively by the four suction nozzles 34. Also, by driving the actuators 40 of all the placement heads not simultaneously but sequentially one by one to thereby lower all the suction nozzles 34 sequentially and in succession, the four electronic components can be placed onto the circuit board 12 sequentially by the four suction nozzles 34 without moving the placement heads within the X-Y plane.

As a result of this, the component placing time can considerably be shortened. It is noted here that Fig. 14A shows a case where the intervals of suction nozzles and the intervals of electronic components are equal to one another ($L_1 = L_2 = L_3 = N_1 = N_2 = N_3$), and Fig. 14B shows a case where the component intervals are different from one another.

In this case, whereas electronic components can be mounted most efficiently by sucking and holding the electronic components by the placement heads in the state shown in Fig. 13A and then placing the electronic components onto the board as shown in Fig. 14A, performing the component placing by, for example, sucking the electronic components in the state of Fig. 13A and then moving the electronic components to the placement head positions shown in Fig. 14B during the move of the transfer

head 29 leads to an improvement in the mounting cycle time.

Intervals between the placement heads at such component feed positions as shown in Fig. 13A, and intervals between the placement heads at such component placing positions as shown in Fig. 14 are set by designating X and Y coordinates of component feed positions and X and Y coordinates of placement positions with an NC program shown in Fig. 15 and previously stored in the storage section 1001 of Fig. 21, reading these X and Y coordinates by control of the control section 52, and calculating with an arithmetic section 1002 of Fig. 21. The NC program is a program for sequentially instructing operations of component mounting for the component mounting apparatus. For example, in the case where the X-coordinates of component feed positions read from the storage section 1001 are k_1 for the placement head 39d, k_2 for the placement head 39c, k_3 for the placement head 39b, and k_4 for the placement head 39a at steps Nos. 1 - 4, the intervals L_1, L_2, L_3 between the placement heads are determined by the arithmetic section 1002 so that the individual placement heads become coincident with the designated component feed positions. In this case, the arithmetic section 1002 performs calculations of $L_1 = k_2 - k_1$, $L_2 = k_3 - k_2$, $L_3 = k_4 - k_3$ to determine the intervals L_1, L_2, L_3 between the placement heads.

Also, in the case where the X-coordinates of component placing positions read from the storage section 1001 are X_{11} for the placement head 39d, X_{12} for the placement head 39c, X_{13} for the placement head 39b, and X_{14} for the placement head 39a at steps Nos. 1 - 4 of Fig. 15, the intervals L_1, L_2, L_3 between the placement heads are determined by the arithmetic section 1002 so that the individual placement heads become coincident with the designated component placing positions. In this case, the arithmetic section 1002 performs calculations of $L_1 = X_{12} - X_{11}$, $L_2 = X_{13} - X_{12}$, $L_3 = X_{14} - X_{13}$ to determine the intervals L_1, L_2, L_3 between the placement heads.

It is noted here that although the change of the intervals between the placement heads at the component feed positions may be done at the component feed positions, yet performing the change of the intervals between the placement heads during the move of the transfer head 29 subsequent to the placing of the one-preceding component allows an improvement in the mounting cycle time to be achieved. It is noted that although the intervals between the placement heads in component suction and component placement operations are determined through calculations by the arithmetic section 1002 based on X and Y coordinates of component feed positions and X and Y coordinates of placement positions in the above example, yet it is also

possible to previously store intervals of the component feeders 30 and/or intervals of placement positions in the storage section 1001 so that placement-head adjustment operation can be done only by reading those intervals without any arithmetic processing. In summary, it is required only that array information, concretely, interval or positional information as to the component feeders 30 or placement positions be stored in the storage section 1001.

Also, the changing of intervals between the placement heads at a component feed position may also be obtained by recognizing component array position information as to marks or the like provided on the component feeders 30 with a camera or sensor or other recognition device 905 (one example of component-array-position-information recognition devices) provided on the transfer head 28 or 29, and performing arithmetic processing with the arithmetic section 1002 to thereby obtain the intervals of the component feeders 30, and adjusting the intervals between the placement heads so that those intervals adjust the obtained intervals of the component feeders 30.

Similarly, it is also possible that with electronic components sucked and held in the state shown in Fig. 13B, component placement is performed by moving the components to placement-head positions shown in Figs. 14A

and 14B.

In any of the above-described ones, component suction or component placement for all the placement heads can be completed by a simultaneous one-time up-and-down motion of the placement heads, so that the component mounting time can largely be shortened.

In addition, the placement-head moving mechanism for moving the placement heads to adjust the intervals of the placement heads may be not only a ball screw mechanism but also any devices whichever can maintain the travel speed and the precision. Further, although the transfer head in the first and second embodiments has a quadruple-placement-head structure, yet the present invention is not limited to this and may be structured so as to have any arbitrary number of placement heads.

The first and second embodiments have been shown above in an arrangement that array intervals of the placement heads are adjusted so as to be respectively coincident with array intervals of the component feeders 30 or intervals of the electronic-component placing positions on the circuit board. However, without being limited to this, it may also be arranged, for example, that array intervals of the component feeders 30 are adjusted by a component-feeder moving mechanism (one example of component-feed-section moving mechanisms) on the basis of

the array intervals of the individual placement heads, or that the intervals of electronic-component placing positions on the circuit board are design-changed. By so doing, the placement-head moving mechanism on the transfer-head side becomes unnecessary, allowing the transfer head to be reduced in weight and the travel speed to be enhanced, so that higher-speed mounting becomes achievable.

Fig. 16 shows a concrete example as a component-feeder moving mechanism 120 (one example of component-feed-section moving mechanisms) for changing the array intervals of the component feeders 30. In the component-feeder moving mechanism 120, feeder stands 111a, 111b, 111c, 111d for setting thereon the component feeders 30 respectively are advanceable and retreatable along a ball screw 110 fixed unrotatable. Inside the feeder stands 111a - 111d, are provided hollow motors 115a - 115d which rotate around the ball screw 110, respectively. The hollow motors 115a - 115d are operated individually and independently of one another by the control from the control section 52, by which the feeder stands 111a - 111d are advanced and retreated along the ball screw 110 individually and independently, so that array intervals M_1, M_2, M_3 of the component feeders 30 can be changed so as to be coincident with the intervals between adjacent placement heads.

Further, if heights of the individual placement

heads can be adjusted vertically so as to be coincident with heights of the components, the components can be sucked or placed while lowering extents for the individual placement heads are adjusted to optimum positions according to the heights of the components.

According to the component mounting method and the component mounting apparatus of the present invention, in the process of mounting components onto a multiple board,

(1) a change of suction nozzles is done after a placement step of placing onto the board all components that can be held by an identical suction nozzle has been applied to all the sub-boards, which makes it possible to suppress the number of times of change of suction nozzles to a minimum;

(2) after a placement step of placing components onto individual sub-boards successively with components of an identical type held by the suction nozzles, respectively, has been applied to all the sub-boards, the working step moves to the next placement step, which makes it possible to replace an operation of repeating suction and placement component by one component with an operation of previously sucking plural components all at a time and placing the components; and

(3) when the placement of components to one sub-board is completed and succeeded by the placement of components

to the next sub-board, the suction nozzle that is the last used for the placement-completed sub-board is used as it is for the next sub-board, which makes it possible to reduce the number of times of change of suction nozzles. By these methods of (1) to (3), mounting operation can be carried out efficiently so as to be free from any waste. Thus, the component mounting time can be shortened and the throughput of equipment can be improved.

Further, by virtue of the arrangement that the component array intervals of the component feed section or the intervals of component placing positions on the board are made coincident with the array intervals of the component holding devices of the transfer head, the components can be held by the component holding devices by a simultaneous one-time up-and-down motion of the component holding devices in taking out the components from the component feed section. Also, in placing onto the circuit board the components held by the component holding devices, the components can be placed to desired positions on the circuit board by a simultaneous one-time up-and-down motion of the component holding devices. Thus, the component mounting time can greatly be shortened.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is

to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.